Subsystem	34" Widescreen Direct View Receiver	56" Widescreen CRT Type Projector
Signal Processing Components	$ 98	$ 98
Audio Amplifiers, Speakers	30	30
Scan System, Power Supply, Video Amps	60	176
Display	700	1,050
Cabinet	90	140
TOTAL MATERIAL COST	$ 978	$1,494

Figure 10-8. Material cost data for a DigiCipher receiver.

10.4 TECHNOLOGY

10.4.1 Audio/Video Quality

In video subjective tests of DigiCipher, the system performed consistently across segments of test material with no difference between still and moving materials. For 8 of the 9 stills and be 0.3 grade (i.e., about 6 points on the 100-point scale) lower in quality than the 1125-line studio reference; for the remaining still (S14), the system was judged to be 0.6 grade higher in quality than the reference (this may reflect reduced visibility of interlacing artifacts in the DigiCipher rendering of this picture). For motion sequences, DigiCipher also was judged, on average, to be 0.3 grade (i.e., about 6 points) lower in quality than the reference.

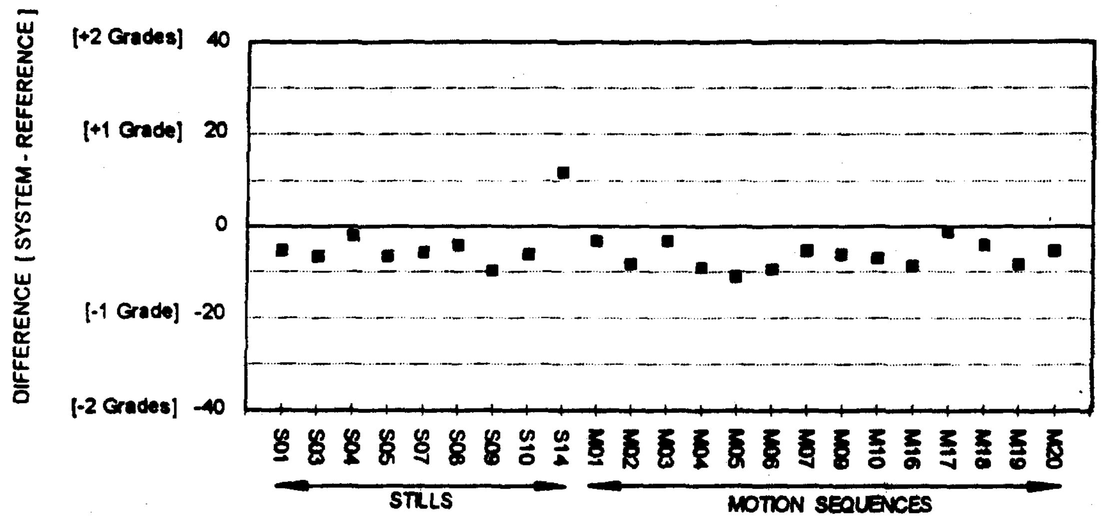


Figure 10-9. Average differences between quality judgments for the 1125-line studio quality reference and for DigiCipher.

DigiCipher performed consistently across all segments of test material. Differences ranged from -0.1 to -0.6 grade (not counting S14). The variability among viewers was consistent across materials and within accepted limits. Expert commentary, supported by reports from the non-expert viewers, attributed the small differences between DigiCipher and the reference primarily to quantization noise (visible in flat areas, as well as at edges and in areas of high detail) and to reduced resolution (especially in colored areas). It is expected, however, that "busy-ness" in areas of high detail (i.e., time-varying noise correlated with image content) and artifacts of periodic PCM updating also may have contributed, but to a lesser extent.

Consistent performance for stills and motion sequences is supported by objective tests of static and dynamic resolution. For luminance resolution, tests show retention of static-level resolution at all but the highest rate of movement. For chrominance resolution, the results were similar; however, lower horizontal and diagonal resolution were noted for the blue channel.[2]

[2] See Section 8.3.5.

When subjected to noisy source material, DigiCipher introduced an increase in visible noise at the output and, for critical sequences, a slight increase in "busy-ness".

When subjected to scene cuts and viewed in real time, DigiCipher introduced no artifacts that were visible in flat fields or in motion sequences, but did introduce artifacts that were visible in highly detailed stills. Examination of freeze frames showed "build up" in resolution following cuts to highly detailed stills with resolution restored almost fully by the second frame and restored fully by the third frame (1/10 second).

Slight system artifacts became visible when material was subjected to two encode/decode passes through the system. During the first pass, DigiCipher introduced a barely perceptible loss in resolution and increase in quantization noise. During the second pass, these artifacts increased slightly and a barely perceptible loss in color was introduced.

The DigiCipher system exhibited good chrominance dynamic range in the red and green channels, but performance was not as good in the blue channel.

When tested for video-coder overload, DigiCipher exhibited no significant failures, but did introduce some quantization noise as well as some "blockiness" and "mottling." When tested for motion-compensation overload with velocities of up to 0.44 picture height per second (the limit of the test software), the system introduced slight quantization noise and occasional "blockiness"; further, the character of the quantization noise changed with velocity of movement, first becoming patterned (i.e., coherent), and then stationary. No artifacts were noted in response to a sudden stop in movement.

The difference in unimpaired video quality between 16 QAM and 32 QAM was evident to both expert and non-expert observers; the performance difference in motion sequences was clearly evident. In video subjective tests of image quality by non-experts, 16 QAM DigiCipher was judged, on average, to be about 0.7 grade lower in quality for stills and 0.9 grade lower in quality for motion sequences than the reference.[3] For the challenging video sequences documented in this report, the experts were almost always able to recognize whether the viewed image was from reference, 32 QAM, or 16 QAM material. The quality of the 32 QAM images was, in general, close to, but distinguishable from, the reference material. Except for the least challenging video sequences, quantization noise was always apparent for 16 QAM coding. Expert commentary noted increased "busy-ness" and more frequent "blockiness" in response to noise in the video source, slower (i.e., 5 frames) recovery of resolution following a scene cut to a highly detailed still, and more visible

10.4.1.2 Audio Quality

There was no evidence that the audio system failed before the accompanying video.[4]

Objective tests were preformed for dynamic range, total harmonic distortion (THD), THD+noise (THD+N), intermodulation distortion (IMD), dynamic intermodulation

10.4.2.1 Noise Performance

When DigiCipher was subjected to random channel noise (based on a 6 MHz noise bandwidth), the carrier-to-noise ratio[5] (C/N) at the TOV was measured and is shown in Figure 10-1. The system had a sharp degradation — the range between TOV and the point of unusability (POU) was 0.5 dB. The carrier-to-noise ratio at the TOV was measured for the 16 QAM Alternate Mode also and found to be 12 dB.

10.4.2.2 Static Multipath

The system performed well at levels that would be highly objectionable in NTSC. The TOV for echoes of -0.08 μsec, +0.08 μsec, +0.32 μsec, and +2.56 μsec occurred at D/U ratios of 6.7 dB (i.e., echo amplitude of 46%), 9.5 dB (33%), 8.9 dB (35%), and 3.6 dB (66%) respectively.

10.4.2.3 Flutter

The TOV for airplane flutter of 2 Hz and 5 Hz were at D/U levels of 14.5 dB (18.8%) and 10.4 dB (30%) respectively.

10.4.2.4 Impulse Noise

Impulse noise performance was judged to be better than NTSC by approximately 10 dB for TOV. The range between TOV and POU was about 4 dB.

In the gated noise test at a fixed 10 Hz repetition rate, TOV was reached when the pulse width was increased to 5 μsec. When the pulse width was decreased to 4 μsec, TOV was reached when the pulse repetition rate was increased to 1.7 kHz.

10.4.2.5 Discrete Frequency Interference

The D/U ratio at the TOV for discrete frequency interference was -27 ($\pm$0.5) dB in the first adjacent channels, and between +7.5 dB and +11.6 dB in-band.

10.4.2.6 Cable Transmission

The subjective tests showed that cable transmission *per se* had no adverse effect on DigiCipher performance.

[5] Caution must be exercised in comparing C/N between analog and digital systems, as definition of carrier levels is not consistent. Measurement of power level is consistent, however, among digital systems. (See section 8.3.6.)

Among the cable-specific tests conducted, the system performed better than NTSC when subjected to hum (TOV > 15%); composite triple beat, or CTB, (TOV @ -31 dBc); and composite second order, or CSO, (TOV @ -16 dBc). Its performance was poorer than NTSC when subjected to phase noise (TOV @ -82 dBc), residual FM (TOV @ 5.7 kHz), and local oscillator instability (+40 kHz, - 60 kHz).

The threshold values for the ancillary data channel (as measured on the second audio channel pair at 251 kbits/sec) were consistent with the values found in other tests for Gaussian noise, CTB, hum modulation, and phase noise.

10.4.2.7 Co-Channel Interference into ATV

DigiCipher was much more robust than NTSC to co-channel interference from either NTSC or ATV. Results are summarized in Figure 10-1. The system performance exhibited a sharp degradation when co-channel interference was increased beyond TOV. The range from TOV to POU was less than 2 dB for NTSC-into-ATV co-channel interference, and approximately 0.5 dB for ATV-into-ATV co-channel interference.

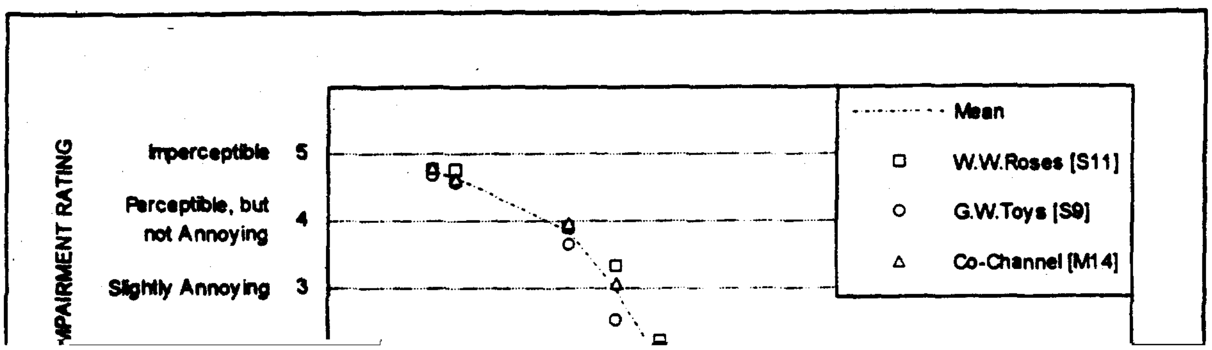
10.4.2.8 Co-Channel Interference into NTSC

For co-channel interference into NTSC, impairment ratings varied gradually from "imperceptible" to "very annoying" over a range of 24 dB at weak desired signal level. (See Figure 10-10). The D/U for a mean impairment rating of 3 was about 35 dB. The interference appeared as random noise, except for a narrow horizontal band where the noise pattern appeared to be fixed.

10.4.2.9 Adjacent-Channel Interference

The D/U ratio at the TOV for adjacent-channel interference into DigiCipher is given in Figure 10-1. The D/U ratio for a mean rating of 3 (slightly annoying) for adjacent-channel interference into NTSC is given also in Figure 10-1. Note that the more negative the D/U ratio, the better the performance. In practice, it is expected that the DigiCipher signal would be transmitted with an average power 10-15 dB lower than NTSC peak power. Under this assumption, the data indicate that DigiCipher supports collocation.

The system exhibited a sharp degradation when subjected to adjacent-channel interference from NTSC and ATV. The range from TOV to POU was about 1 dB.


IMPAIRMENT RATING
Imperceptible 5
Perceptible, but not Annoying 4
Slightly Annoying 3
Mean
W.W.Roses [S11]
G.W.Toys [S9]
Co-Channel [M14]

CHANNEL	ATV-into-NTSC		NTSC-into-ATV		ATV-into-ATV	
	Strong	Weak	Strong	Weak	Strong	Weak
n+2	< -1*	-30	-29	-34	-29	-36
n-2	< +4*	-25	-34	-45	-30	-38
n+4	< -4*	-27	<-33*	-58	<-33*	-57
n+7	< +2*	-39	<-33*	<-58*	<-33*	-59
n-7	< +2*	-35	<-33*	-58	**	-57
n+8	< +2*	<-38*	<-33*	<-58*	<-33*	<-63*
n-8	< -2*	-34	<-33*	-58	**	-58
n+14	< -2*	-27	<-33*	<-58*	<-33*	<-63*
n+15	-2	-17	<-33*	<-58*	<-33*	<-63*

* Determination of TOV level was beyond the limits of ATTC's RF test bed range. Consequently, the system performance was better than the indicated result.

** Test not performed.

Figure 10-11. Taboo threshold of visibility for DigiCipher (D/U in dB).

During a loss of signal, or when the signal was overwhelmed with impairments, the whole screen image froze, sometimes with errors displayed. Recovery from a loss of signal was through a right-to-left wipe in four distinct vertical panels. The wipe transition was about 1/3 second or less.

10.4.2.13 Peak-to-Average Power Ratio

The peak-to-average power ratio for the 32 QAM mode was less than 4.8 dB 99% of the time, and less than 6 dB 99.9% of the time. For 16 QAM, these ratios were 4.6 dB and 5.7 dB respectively.

10.4.2.14 Multiple Impairments

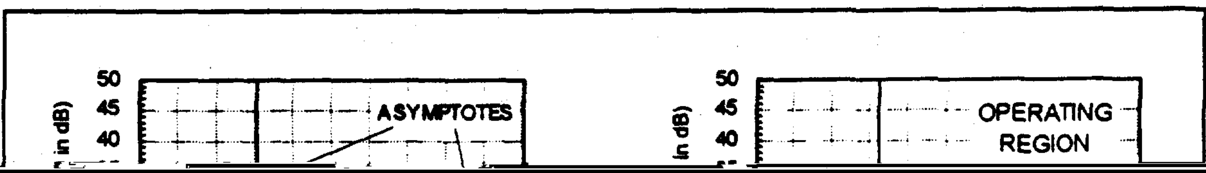
The performance of DigiCipher when simultaneously subjected to multiple impairments, is shown in Figure 10-12 for two cases:

(1) The POA[6] for NTSC co-channel interference versus random noise, and

(2) The TOV for composite triple beat versus random noise.

[6] For the DigiCipher system, the POA and TOV differ by less than 1 dB.

Asymptotes are shown reflecting the measured single impairment performance. The operating region lies above and to the right of the respective curves.



cassettes similar in format to 8-mm NTSC cassettes. The proponent reports running simulations showing that a full set of trick mode features can be supported. In the trick mode simulations, the DigiCipher VCR uses PCM refresh data from each field and attempts to use DPCM data also. Switching between compressed video images should be done at frame sync, preferably with the new scene at black, or at a scene change when the image is being processed in the PCM mode. Switching within a frame may be done at the macroblock level with some restrictions. Otherwise, editing during frames requires decompression and recompression with a small loss in quality due to concatenation. However, it is anticipated that most editing will be done prior to compression.

10.4.4 Extensibility

10.4.4.1 To No Visible Artifacts

The proponent reports simulating compression at 30 Mbits/sec with favorable results, and believes that the algorithm can be extended to 40-45 Mbits/sec which would constitute a distribution level of quality suitable for network feeds to local affiliates. The proponent is investigating an approach that would allow the transmission-level signal to be included in the distribution-level signal as a kernel. This would permit pass-through of the transmission-level signal at the local affiliate level by stripping away the distribution-level augmentation.

10.4.4.2 To Studio Quality Data Rate

The proponent speculates that studio quality intraframe compression can be achieved at a bit rate in the 100-200 Mbits/sec range. This format has not been developed yet.

10.4.5.2 With Digital Technology

Because this system is all-digital, the advantages of all-digital systems apply.

10.4.5.3 Headers/Descriptors

The proponent discussed the use of the ancillary data space for transmitting the program name, remaining times, and program rating. In the system tested, there is a 7-byte header at the beginning of each data frame; three bytes are available. There is a one-byte header at the beginning of each video frame; one bit is available. There is a fully defined two-byte header at the beginning of each macroblock.

10.4.5.4 With NTSC

The proponent selected the field rate of 59.94 Hz for compatibility with NTSC. The number of active video lines was selected to be double the number of active NTSC lines. Down-conversion involves interpolation between HDTV pixels in a line and between HDTV lines.

10.4.5.5 With Film

The tested system accepts 24 fps film, converted using 3:2 pull-down to 59.94 Hz video, 2:1 interlaced. The DigiCipher encoder recognizes the redundancy in each five-field sequence as having originated in 24 fps film and converts the 59.94 fields/sec video back to 23.98 frames/sec. The image is processed and transmitted as 23.98 frames/sec progressive. It is converted back to 59.94 fields/sec interlace in the decoder using 3:2 pull-down. Future receivers could alternatively use 3:1 frame repeat to display progressive at 72 Hz. Film at 30 fps, delivered to the encoder as 59.94 fields/sec video, can be processed and transmitted as 29.97 frames/sec progressive. The benefit is more efficient coding, and thus higher quality.

10.4.5.6 With Computers

Progressive scanning and square pixels, not included in the DigiCipher system tested, are important factors for interoperability of an HDTV system with computers. The system has pixels that are 21% wider than high. The tested system was built to select between field processing and frame processing for each superblock, depending on its motion, in order to provide optimum motion handling. However, computer interoperability would be enhanced if the encoder were forced to do frame processing on all superblocks. With this feature, coding and transmission would be in progressive form. The proponent has proposed adding this feature as an option at the encoder.

10.4.5.7 With Satellites

Satellite transmission of the DigiCipher HDTV signal has been demonstrated using QPSK in a 24-MHz bandwidth achieving a raw data rate of 39 Mbits/sec. Instead of the trellis coding used in the terrestrial system, convolutional coding with a Viterbi decoder was used. The coding was rate -1/2; the data rate after Viterbi decoding was 19.51 Mbits/sec. Reed-Solomon coding was used also with the information rate being 18.2 Mbits/sec, identical to the terrestrial signal. A 5.5 dB C/N threshold was achieved, an improvement over the 8+ dB threshold typically achieved in NTSC satellite transmission. The proponent recommends using rate -3/4 coding to yield a 50% increase in the information rate. This would support a higher-level compressed HDTV signal, or an NTSC signal sharing the channel with the HDTV signal. In a 36-MHz transponder, two transmission-quality HDTV signals, or alternatively one distribution-quality 40-45 Mbits/sec signal, can be transmitted.

10.4.5.8 With Packet Networks

In the system tested, the data is packaged into fixed-length data lines, 1160 bits long. Data space was reserved in each data line which could have been used as a header. For lost data lines, the decoder will use error concealment which is already implemented to handle transmission errors.

10.4.5.9 With Interactive Systems

According to the proponent, the latency of DigiCipher is 83 msec. Acquisition time is reported in Section 10.4.2.11.

10.4.5.10 Format Conversion

10.4.5.10.1 With 1125/60

Up-converting to the Common Image Format (1920 x 1080) requires 8:9 vertical

10.4.5.10.3 With MPEG[7]

The DigiCipher decoder would require modification to decode MPEG-1. The proponent claims that there would be a modest increase in complexity because DigiCipher shares many commonalties with MPEG-1. MPEG-1 decoders will not decode DigiCipher.

10.4.5.10.4 With Still Image

The proponent has identified still-frame as a useful capability, and believes that forward compatibility with JPEG, Photo CD and CD-I is feasible. The proponent claims that receivers can be built to decode JPEG, Photo CD, and CD-I if the marketplace supports such products. The frame-coding option offered by the proponent enhances compatibility with still images.

10.4.5.11 Scalability

Though the receive and display clocks are currently linked, the proponent proposes to operate them independently in the future. The receiver could then receive non-real-time video at slower rates. According to the proponent, picture-in-picture and picture-out-of-picture are possible with DigiCipher as receiver design options.

DigiCipher processes the image in four parallel panels. Each panel processor is comparable to a DigiCipher NTSC processor and thus is able to process a DigiCipher NTSC signal. There is also a compatible bus that can support both NTSC and HDTV signals. The proponent claims that the compatibility extends to VCRs and satellite and cable receivers.

10.5 SYSTEM IMPROVEMENTS

10.5.1 Already Implemented

10.5.1.1 Error Concealment

The purpose of this improvement was to reduce the visibility of uncorrected transmission errors and to reduce the visibility of the refresh at the end of error concealment. During error concealment, tainted macroblock update data is not used; prior frame data is carried over instead. Interpanel communication has been added. With the improvement, normal panel right-to-left motion is maintained by importing data from the adjacent panel. The change impacts only the decoder.

[7] See Section 8.3.8 for a discussion of MPEG, the MPEG-1 standard, and the MPEG-2 development effort.

10.5.1.2 Encoder IF SAW Filter

To reduce ATV lower adjacent-channel interference into NTSC, the encoder IF SAW filter has been replaced. The new filter reduces the out-of-band response along the lower skirt.

10.5.1.3 Tuner IF Filters

To improve adjacent-channel rejection and close-in taboo performance, the receiver 1200 MHz and 43.5 MHz IF filters have been modified to tighten the passband.

10.5.1.4 Peak-to-Average Ratio

An adjustable clipping amplifier has been added in the encoder just ahead of the IF SAW filter. The SAW filter suppresses out-of-band spurious signals which might be generated by the clipping operation. Since the signal stays within a few dB of its average the vast majority of time, the improvement allows a reduction in peak-to-average ratio with an offsetting fractional reduction in C/N threshold performance and some possible reduction in interference performance when the ATV signal is the interferor. For field testing, clipping will be set at the ATTC measured maximum peak value, 7 dB.

10.5.2 Implemented in Time for Field Testing

10.5.2.1 Packetized Transmission

In order to support ATSC T3/186 flexibility requirements, packetizing will be implemented at the transport layer. The packet length will be 155 bytes, identical to the current data line structure. The change involves organizing packets by data type, rather than the current data multiplexing within a line, and inclusion of a header at the beginning of each packet. The modification affects both encoder and decoder.

10.5.2.2 Multichannel Sound

The purpose of this improvement is to implement ATSC T3/186 audio features, including composite-coded multichannel surround sound. The system will incorporate two Dolby Laboratories AC-3 encoders on the transmit side and one AC-3 decoder in the receiver. The AC-3 system is flexible with numerous modes of operation, including 5.1 channel composite-coded surround sound, or two independently coded AC-2A channels.

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11. DIGITAL SPECTRUM COMPATIBLE HDTV

11.1 SYSTEM OVERVIEW

DSC-HDTV, proposed by Zenith and AT&T, is a digital simulcast system that requires a single 6 MHz television transmission channel.[1] The video source is an analog RGB signal with alternate 787/788 lines, progressively scanned, a 59.94 Hz frame rate, and an aspect ratio of 16:9. The display format is 720 lines by 1280 pixels per line. The video sampling frequency is 75.3 MHz. Chrominance signals are decimated by a factor of two both horizontally and vertically. Nine-bit precision is employed for all luminance and chrominance samples. The video compression includes perceptual coding, vector quantization, and adaptive fractional leak. Motion is estimated by hierarchical block matching with 1/2 pixel accuracy. A displaced frame difference (DFD) is computed and transformed with a Discrete Cosine Transform (DCT). Block sizes for motion compensation, varying from 32H x 16V to 8 x 8, are adapted spatially to places in the image providing the most benefit. Time division multiplexing between 4-level and 2-level VSB transmission is employed to provide improved error performance and extended coverage. The amount of time at each level depends on the complexity of the image being processed, with more complex images requiring more 4-level data. To provide a measure of "graceful degradation," certain critical data are always transmitted in the more rugged 2-level mode. In addition to the Standard Mode, the DSC-HDTV system also offers a Robust Mode, which increases the ratio of 2-level to 4-level data that is transmitted. The variable length codes are packed into slices (64H x 48V) with a header providing identification of the first slice boundary in each segment to allow restart of the variable length decoding. Transmission is by vestigial sideband modulation with a pilot carrier 0.31 MHz above the lower edge of the 6 MHz channel. Video data rate ranges from 8.45 to 16.92 Mbits/sec and the total transmission rate ranges from 11.14 to 21.0 Mbits/sec. The system employs a post-comb-filter in the receiver which automatically switches in to minimize the effects of NTSC co-channel interference. The DSC-HDTV system provides four digital audio channels using Dolby Laboratories AC-2 compression system. The audio is sampled at 47 kHz, the horizontal scan rate, with 16 bit precision. The compressed audio rate is 252 kbits/sec per constraints (considering only co-channel interference, and both co-channel and adjacent-channel interference). In addition, the impact of taboos was assessed by re-calculating coverage and interference for each case assuming the taboo performance measured in the laboratory.

Figure 11-1 shows planning factors, specific to the DSC-HDTV system, as derived from test results. The numbers in the figure are desired-to-undesired ratios (D/U) in dB. The values for interference into NTSC are based on CCIR Impairment Grade 3 (slightly annoying) as determined from the ATEL subjective tests. Because the ATV service is intended to be an improvement over NTSC, interference into ATV is based on CCIR Impairment Grade 4 (perceptible but not annoying) if the range between the threshold of visibility (TOV) and the point of acquisition (POA) exceeds 5 dB. Otherwise, the TOV power level is used. DSC-HDTV demonstrated a "cliff effect" except for the case of co-channel NTSC-into-ATV; D/U values are based on TOV data.[2] Also, the data show that DSC-HDTV can support collocation on both the upper and lower adjacent-channels.

Co-Channel	D/U (dB)
ATV-into-NTSC	+35
NTSC-into-ATV	+3.5
ATV-into-ATV	+18.2

Carrier-to-Noise	+16.0

Adjacent-Channel	D/U (dB)
Lower ATV-into-NTSC	-17.2
Upper ATV-into-NTSC	-7.5
Lower NTSC-into-ATV	-43
Upper NTSC-into-ATV	-42
Lower ATV-into-ATV	-35
Upper ATV-into-ATV	-36

Figure 11-1. Planning factors specific to DSC-HDTV.

11.2.1 Accommodation Percentage

DSC-HDTV could provide a 100% accommodation of all NTSC assignments for co-channel only, and co-channel and adjacent-channel constraints, under both the VHF/UHF and UHF scenarios. The accommodation is achieved at the expense of reducing the ATV and NTSC service areas. No attempt was made to reduce interference to NTSC service by adjusting either ATV or NTSC power.

[2] The range between TOV and POU for Co-Channel NTSC-into-ATV was 7 dB. The weak level ATEL impairment tape showed unexpectedly large amounts of impairments starting at TOV. This result was anomalous. Because it was not possible to derive an agreeable CCIR Impairment Grade 4 rating, the weak level TOV was used for spectrum utilization analyses.

11.2.2 Service Area

Figure 11-2 depicts the interference-limited service area of each ATV station, during the transition period, relative to the interference-limited service area of its companion NTSC station under the VHF/UHF scenario, taking into account both co-channel and adjacent-channel constraints. In this graph, the 1,657 current NTSC stations are placed in order of decreasing ATV to NTSC service area ratio. Examination of the graph reveals that 13.2% (218) of the ATV stations under this scenario would have an ATV service area at least 20% larger than their companion NTSC service area and 98% (1,624) would have an ATV service

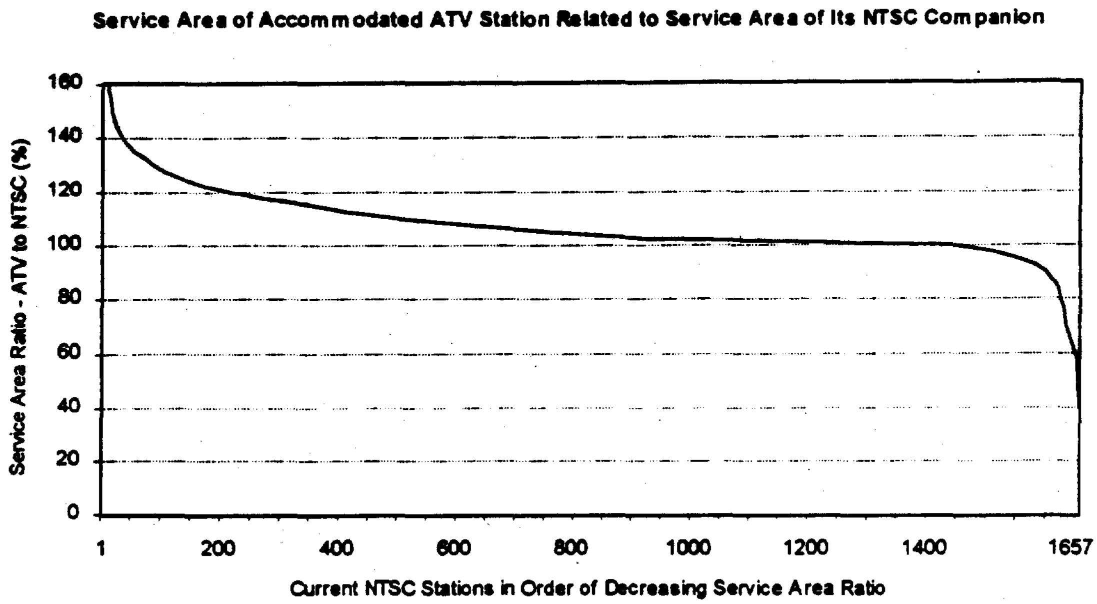

Figure 11-2. DSC-HDTV VHF/UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	59.9 %	71.7 %	58.2 %
0 - 5 %	20.8 %	16.5 %	16.3 %
5 - 10 %	9.2 %	5.9 %	8.9 %
10 - 15 %	4.6 %	2.5 %	5.4 %
15 - 20 %	1.6 %	0.8 %	4.6 %
20 - 25 %	1.3 %	0.6 %	1.7 %
25 - 30 %	0.7 %	0.4 %	1.6 %
30 - 35 %	0.6 %	0.5 %	0.8 %
> 35 %	1.3 %	1.1 %	2.4 %

Figure 11-3. DSC-HDTV VHF/UHF Scenario — Interference characteristics (co-channel and adjacent-channel constraints).

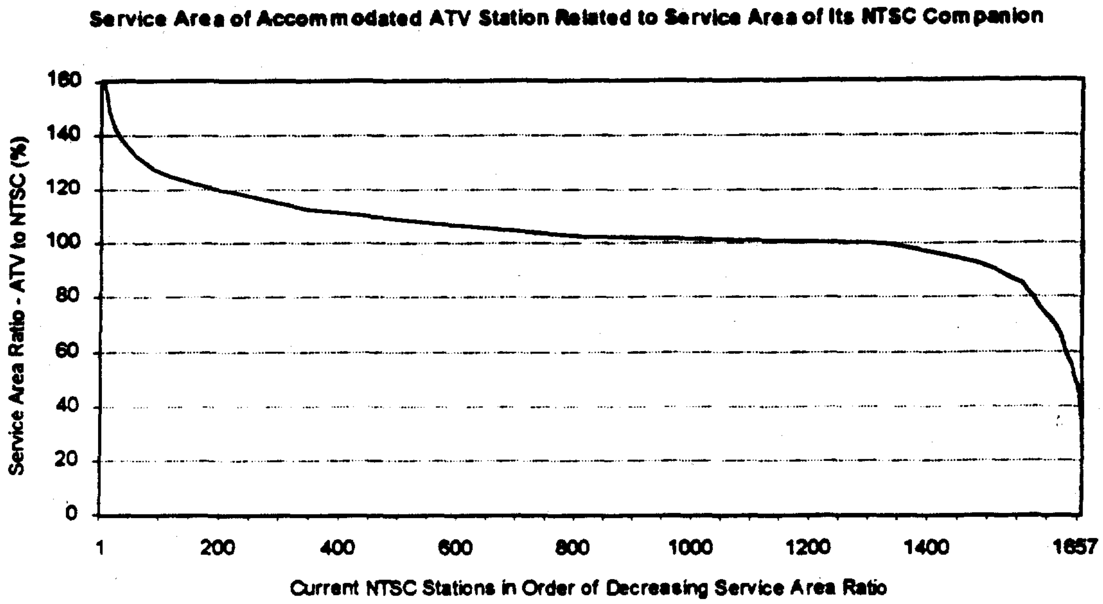

Figure 11-4. DSC-HDTV UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	54.3 %	64.8 %	61.1 %
0 - 5 %	15.2 %	14.5 %	9.4 %
[illegible]	[illegible]	[illegible]	[illegible]

station under the UHF scenario, taking into account both co-channel and adjacent-channel constraints. In this graph, as before, the 1,657 current NTSC stations are placed in order ofdecreasing ATV to NTSC service area ratio. Examination of the graph reveals that 11.9% (198) of the ATV stations under this scenario would have an ATV service area at least 20% larger than their companion NTSC service area and 95% (1,577) would have an ATV service area at least 80% of their companion NTSC service area. The total ATV interference-limited service area for all 1,657 stations is 39.8 million square kilometers.

Figure 11-5 shows the interference statistics for the UHF scenario. During the transition period, 54.3% of ATV stations would receive no interference. This would rise to 64.8% after the transition period ends. Also during the transition period, 3.0% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 2.9% after the transition period ends. The total interference area created within the ATV noise-limited coverage area during the transition period is 2.46 million square kilometers. This would decrease to 1.78 million square kilometers after the transition period ends. Of the existing NTSC stations, 61.1% would not receive any new interference because of the ATV service, while 8.0% would receive new interference in more than 35% of their Grade B coverage area. The total new interference created under this plan is 2.26 million square kilometers.

When taboos are included in the interference calculations for the UHF scenario, the number of ATV stations with no interference during the transition period is 52.1%; the number of ATV stations with interference in more than 35% of their noise-limited coverage area is 3.1%. The number of NTSC stations receiving no new interference is 57.2%; the number of NTSC stations with interference in more than 35% of their Grade B area is 8.0%.

When the adjacent-channel constraints of Figure 11-1 are not included in the UHF scenario, the allotment/assignment table is different. In that case, 14.0% (232) of the ATV stations would have an ATV service area at least 20% larger than their companion NTSC service area

Average Effective Radiated Power Level		Number of TV Stations			
		VHF/UHF Scenario			UHF Scenario
(dBk)	(kW)	Low VHF	High VHF	UHF	UHF
Less than 5	Less than 3.2	12	24	100	100
5 - 10	3.2 - 10.0	3	8	47	48
10 - 15	10.0 - 31.6	2	11	127	136
15 - 20	31.6 - 100		4	253	260
20 - 25	100 - 316			287	301
25 - 30	316 - 1,000			241	255
30 - 35	1,000 - 3,160			316	326
35 - 40	3,160 - 10,000			222	231
> 40	> 10,000				
TOTAL		17	47	1,593	1,657

Subsystem	Cost (thousands)
Satellite Receiver, Demodulator, Decoder	$ 13.5
Character Generator, Still Store, Two 28" Monitors	200.0
Routing Switcher (10 x 10), Master Control	125.0
2 ATV VTRs and Monitors	170.0
NTSC Upconverter, including Line Tripler	24.0
ATV-to-NTSC Downconverter	20.0
34" Monitor, Seven 17" Monitors, Eight Decoders	119.0
ATV Encoder	240.0
STL Subsystem	92.5
ATV Modulator, ATV Exciter	30.0
ATV Transmission Subsystem	725.5
TOTAL COST	$1,759.5

Figure 11-7. Equipment cost for a DSC-HDTV transitional station.

Subsystem	34" Widescreen Direct View Receiver	56" Widescreen CRT Type Projector
Signal Processing Components	$ 116	$ 116
Audio Amplifiers, Speakers	30	30
Scan System, Power Supply, Video Amps	73	201
Display	700	1,050
Cabinet	90	140
TOTAL MATERIAL COST	$1,009	$1,537

Figure 11-8. Material cost data for a DSC-HDTV receiver.

Using a 2.5 multiplier, the resulting estimated retail price for a DSC-HDTV receiver is $2,523 for a 34" direct view receiver and $3,843 for a 56" projector receiver.

11.4 TECHNOLOGY

11.4.1 Audio/Video Quality

In video subjective tests of DSC-HDTV, the system performed differently across segments of test material. For 8 of the 9 stills, DSC-HDTV was judged, on average, to be about 0.5 grade lower in quality than the 1125-line studio reference. For 13 of the 14 motion sequences, DSC-HDTV was judged to be about 1.2 grades lower in quality than the reference. The remaining still and the remaining motion sequence, both electronically generated, were judged to be better in quality than the reference.[3]

Problems were noted when the system was subjected to noisy source material, scene cuts, and two encode/decode operations. No significant problems were reported when the system was subjected to a sudden stop in motion or tested for video-coder or motion-compensation overload.

Certain tests also were carried out for the Robust Mode. When judged by non-experts, the Robust Mode exhibited a greater reduction in quality than the Standard Mode for a number of segments of test material. Expert observers always could tell the difference between Standard Mode and Robust Mode.

There was no evidence that the audio system failed before the accompanying video.

11.4.1.1 Video Quality

Subjective judgments of image quality by non-experts are summarized in Figure 11-9. Scores are the differences between judgments of the reference and judgments of DSC-HDTV for 9 stills and 14 motion sequences. For 8 of the 9 stills, DSC-HDTV was judged, on average, to be 0.5 grade (i.e., about 9 points on the 100-point scale) lower in quality than the 1125-line studio reference; for the remaining still (S14), the system was judged to be 0.7 grade higher in quality than the reference (this may reflect the absence of interlacing artifacts in the 787/788 source and in the DSC-HDTV rendering of this picture). For 13 of the 14 motion sequences, DSC-HDTV was judged, on average, to be 1.2 grades (i.e., about 24 points) lower in quality than the reference[4]; for the remaining sequence (M16), the system was judged to be 0.7 grade higher in quality than the reference (this probably reflects the absence of interlacing artifacts in the 787/788 source and in the DSC-HDTV rendering of this picture).

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[3] See Section 8.3.3.

[4] The 787/788 progressively scanned camera material used in testing DSC-HDTV exhibited horizontally coherent noise and increased random noise as compared with the cameras used for 1125-line reference images. See Section 8.3.4.

Figure 11-9. Average differences between quality judgments for the 1125-line studio quality reference and for DSC-HDTV.

DSC-HDTV performed differently for different segments of test material. For stills, differences ranged from +0.2 to -1.2 grades (not including S14); for moving sequences, differences ranged from -0.8 to -1.8 (not including M16). The variability among viewers differed somewhat across materials, but was within acceptable limits. Expert commentary, supported by reports from non-expert viewers, attributed differences between DSC-HDTV and the reference for stills to constant "busy-ness" in detailed areas and to reduced chrominance resolution. Expert commentary, again supported by reports from non-expert viewers, attributed differences between DSC-HDTV and the reference for motion sequences to occasional "blockiness" in the flat areas of sequences that elsewhere contained significant amounts of moving detail, to visible noise that "pulsed" at a low temporal frequency, to reduced resolution, and to exaggeration of source noise, which became coarser and "blocky" after processing.

Objective tests of static and dynamic resolution showed slight losses in horizontal, vertical, and diagonal luminance resolution at high rates of movement.[5]

When subjected to noisy source material, the system introduced an increase in noise at the output (which tended to be more coarse than at the source as well as blocky). In addition, the system introduced blur, "blockiness," and shimmer. At the highest level of source noise tested, pictures from the system were judged unusable by expert observers.

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[5] See Section 8.3.5.